



EXPERIMENT 2

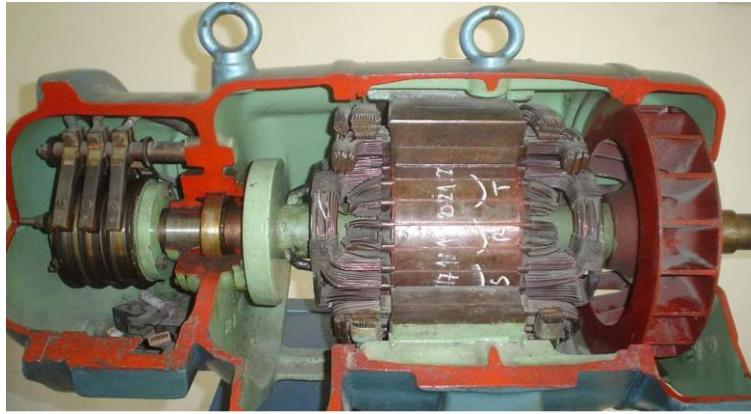
THREE PHASE INDUCTION MOTOR, PART 1

OBJECTIVES

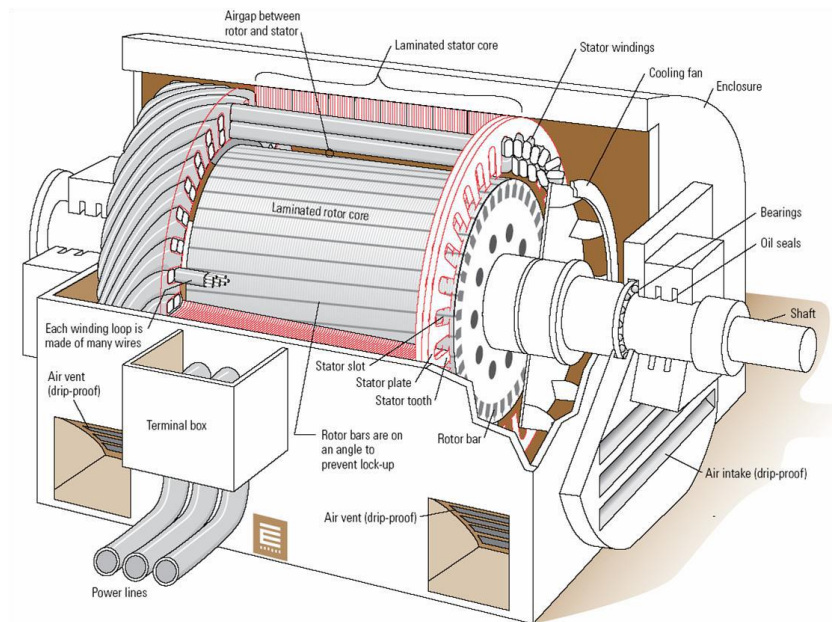
- To understand the principle of operation and the construction of the three phase induction motor.
- Start the three phase induction motor via star-delta connection using Contactors, Start and reverse the direction of the three phase induction motor via star-delta connection using contactors

THEORY

An induction motor is one in which alternating current is supplied to the stator directly and to the rotor by induction or transformer action from the stator. When excited from a balanced three-phase source, the stator winding will produce a magnetic field in the air gap rotating at synchronous speed as determined by the number of stator poles and the applied stator frequency. The rotor of a three-phase induction machine may be one of two types. A wound rotor is built with a three-phase winding similar to, any wound with the same number of poles as, the stator. The terminals of the rotor winding are connected to insulated slip rings mounted on the shaft as shown in Figure 1(a). Carbon brushes bearing on these rings make the rotor terminals available external to the motor. The second type is squirrel-cage rotor with a winding consisting of conducting bars embedded in slots in the rotor iron and short circuited at each end by conducting end rings. The three-phase induction motor with squirrel-cage rotor is shown in Figure 1(b).



(a)



(b)

Figure 1: Cutaway view of a three-phase (a) wound-rotor and (b) squirrel-cage induction motor.

DIRECT ON LINE OPERATION

The direct-on-line (DOL) motor start is the easiest method for starting up three-phase asynchronous motors. The stator windings are directly connected to the mains supply in a single switching process. Large starting currents (surge currents) result by applying the full mains voltage, which in turn cause troublesome voltage changes on the mains supply. For small size motor (less than 2 HP) where starting torque is about twice the full-load torque and starting period lasts only a few seconds, this type starter is used. The schematic diagram for DOL starter is shown in the Figure below.

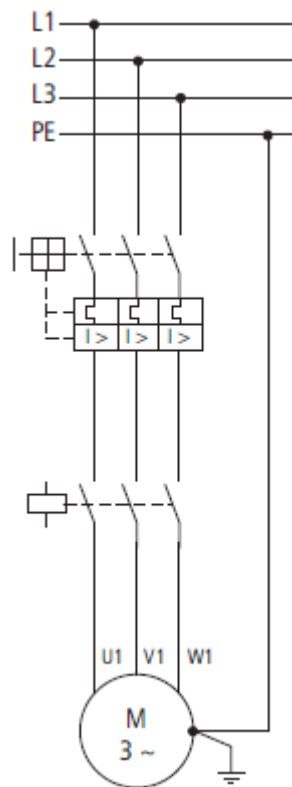


Figure 2: Direct on line motor starter.

STAR DELTA CONNECTION

With a star-delta motor start, the start-up of the three-phase asynchronous motor is implemented by a changeover of the windings. During the operating connection, the windings of the motor are connected in delta. The winding voltage must therefore be equal to the phase voltage of the three-phase system. For example, at a mains supply voltage of 3 ϕ AC 400 V the voltage ratings on the rating plate of the motor must be specified as 400/690 V. In a star connection, the mains voltage on the individual motor windings is reduced by a factor of $1/\sqrt{3}$. For example: $400/\sqrt{3}$ V = 230 V.

Starting torque and inrush current are (in the star connection) reduced to about a third of the values for the delta connection.. Due to the reduced starting torque, the star-delta configuration is only suitable for drives with smaller load torques or load torques that increase with speed, such as is the case with pumps and fans (ventilators/blowers). They are also used where the drive is only subject to a load after it has accelerated up to speed, for example, with presses and centrifuges.

With the changeover of the circuit configuration from star to delta, the current drops to zero, and the speed of the motor reduces depending on the load. The changeover to delta then causes a dramatic rise in the current, as the full mains voltage is now applied to the motor windings. Voltage dips will result on unreliable or weak supply systems. The motor torque also jumps to a higher value during changeover, which causes additional loading on the entire drive system. If, for example, pumps are operated with star-delta starters, a mechanical damper is often used to provide system damping

and to prevent a critical “water hammer” to the system. Automatic changeover from star to delta is usually controlled by a timing relay on the contactor circuit. The time required for starting in the star connection is dependent on the load on the motor and should continue until the motor has reached about 75 to 80 % of its operating speed to ensure that the least possible post-acceleration is necessary after changeover to delta. This post-acceleration is associated in delta configuration with high currents just as is the case with direct-on-line starting. Switching over too quickly between star and delta can result in disconnection arcing (on the switching contacts) and can cause a short circuit. The changeover time interval should be selected so that it is long enough to quench the arcs. At the same time, the speed of the drive should be reduced as little as possible. The correct phase sequence for the changeover from star to delta must be observed when connecting the conductors to the motor and starter. The operating direction of the motor must be considered and observed. Incorrect connection of the phases can cause very high peak currents at restart, because of the slight drop in speed during the de-energized changeover interval. The current peaks endanger the motor windings and stress the switchgear contacts unnecessarily.

CONTACTORS

Contactor is a basic component that functions as a switch rather they are advanced form of switches. They are commonly used to control motors and to perform opening/closing operations.. It consists of two contact parts- stationary and movable. Whole circuit is connected to the stationary part and the movable part consists of a coil. When the coil is energized the movable contacts are closed against the stationary contacts, and the circuit gets completed. Ordinary relays are normally used for low current but contactors are used for switching operations at higher values of currents. Three contactors 16 Amp, 415V are used in the lab. The coil specifications are 220 V, 50 Hz. Here the contactors are operated through push buttons.

APPARATUS

Power Supply Module

3 ϕ induction Motor

AC Ammeter (0-10A)

AC Voltmeter (0-1000V)

Wattmeter 2KW

Contactors 16A, 415V (230V, 50 Hz coil)

PROCEDURE

CAUTION! – High voltages are present in this Experiment. DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after every measurement.

1. MOTOR SPECIFICATIONS

- Refer to the name plate of the 3 ϕ induction motor and list the rated voltage, the rated current, the power and frequency.

Rated Voltage	Rated Current	Power	Rated speed	Rated Torque	Starting Torque	Frequency

2. DIRECT ON LINE STARTER

- a) Make the connection as shown in Figure 3.
- b) Connect the motor in Delta and switch ON the DOL starter and instantly note down the initial current.
- c) When motor attain the rated speed note down the voltage, current and speed of the motor.
- d) Switch OFF the power supply and disconnect the motor.
- e) Connect the motor in Star and re do the steps b-d.

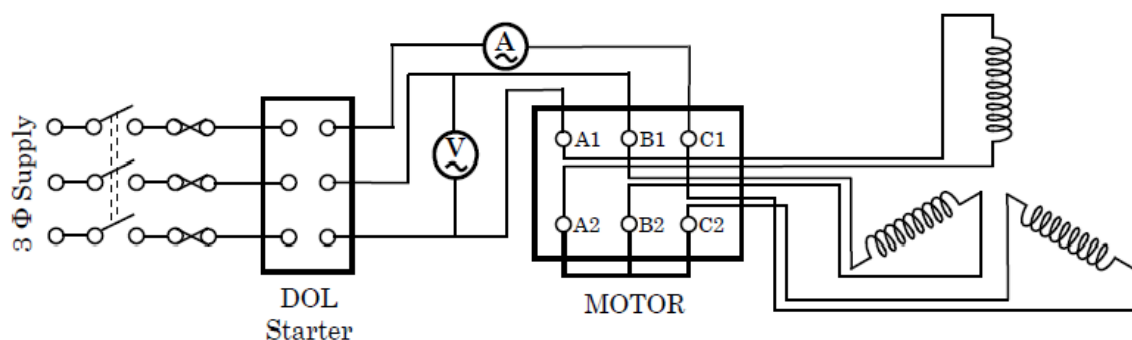


Figure 3: Connection Diagram for DOL starter.

When starting in the star connection, the star contactor first of all connects the winding ends U2, V2, W2. Then the main contactor applies the mains voltage (ULN) to the winding ends U1, V1, W1. After the set starting time has timed out, the timing relay switches off the star contactor, and the delta contactor connects terminals U2, V2 and W2 to the mains voltage.

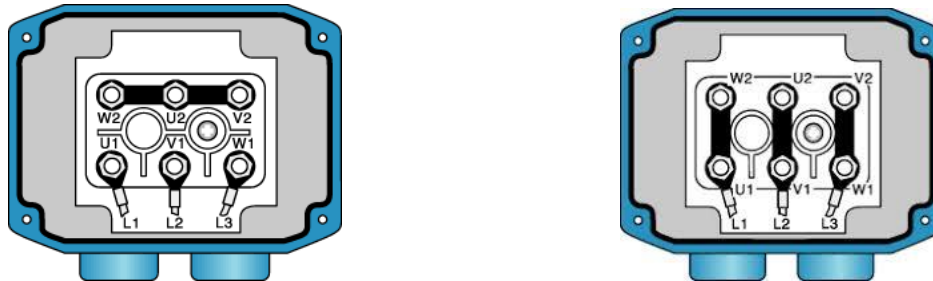


Figure: Motor terminal for star delta connections.

	Voltage	Starting Current	No Load Current	Speed	Slip
Delta					
Star					

3. FORWARD / REVERSE OPERATION

When a squirrel-cage rotor is placed inside a rotating magnetic field, it is pulled around in the same direction as the rotating field. Interchanging the power connections to two of the stator windings (interchanging A with B for example) interchanges two of the three currents and reverses the phase sequence. This causes the rotating field to reverse direction. As a result, the direction of rotation of the motor is also reversed. The power diagram for reversing the direction of rotation of the motor and the associated control circuits are shown in Fig. 4.

- Using two push buttons, build the circuit that controlling the direction of rotation of the three phase induction motor.

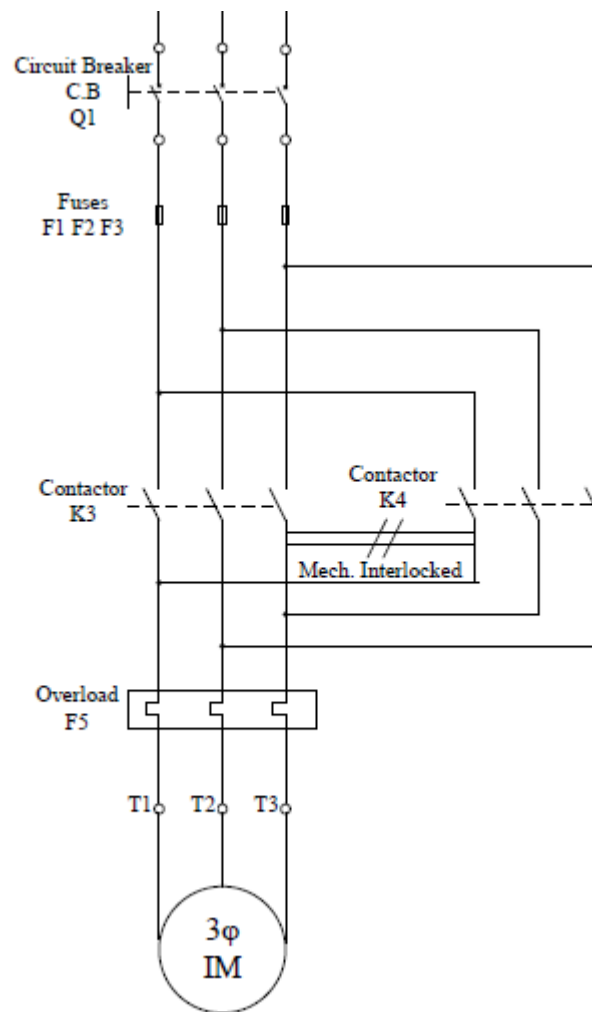


Figure 4: Reversing direction of rotation of a three phase induction motor, Power diagram

- Draw the electrical diagram of your circuit.

4. DELTA - STAR STARTER

- Make the connections as shown in the circuit diagram.
- Set the timer at suitable value.
- Check the three phase supply at the voltmeter.
- Check the sequence of the operations of the contactors after switching the start button.
- Record the no-load current at starting and at rated speed.

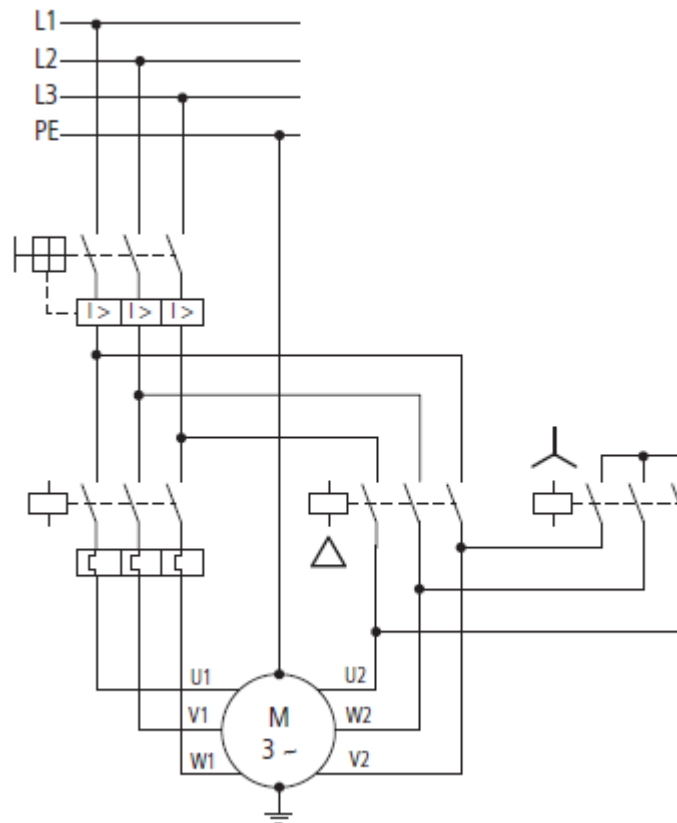


Figure 5: Power diagram for star-delta starter,